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MORPHOMETRIC CHARACTERISTIC OF GLANDULAR STOMACH AND GIZZARD OF THE COMMON SCOTER *MELANITTA NIGRA* (AVES, ANSERIFORMES) WINTERING ON THE POLISH BALTIC COAST

E. Działa-Szczepańczyk

Agricultural University, Judyma str., 20, Szczecin, 71—466 Poland
E-mail: ewa.dziala-szczepanczyk@biot.ar.szczecin.pl

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Morphometric Characteristic of Glandular Stomach and Gizzard of the Common Scoter *Melanitta nigra* (Aves, Anseriformes) Wintering on the Polish Baltic Coast. Działa-Szczepańczyk E. — The material for studies were stomachs of 52 individuals of the Common Scoter *Melanitta nigra* obtained in winter in western parts of Polish Baltic coast. Six parameters of stomachs were established: glandular stomach weight (GSW) and length (GSL), gizzard length (GL) and width (GWi), combined length of both stomachs (GGL), and four measurements describing the birds' body size: body weight (BW) and length (BL), sternum length (SL) and tarsus length (TL). Dimorphic differences connected with the birds' sex and age in concerning average values of stomachs parameters and indices of their relative size were examined. Relationships among values of the stomach parameters and relationships between the values of the stomach parameters and the measurements describing the bird body size were analysed. Despite clearly marked sexual dimorphism in the bird body size in favour of males, only in three parameters GWi, GW, GGL, and in the index GGL/SL (both stomach length in relation to sternum length) drakes achieved significantly higher values than ducks. Adult and immature birds, both in the group of males and females, did not differ in body size and most average values of the stomach parameters. Only in the group of females adult individuals were characterised with heavier gizzard than immature individuals, and adult individuals of both sexes had wider gizzard than immature individuals. Except GSL and GSW, remaining parameters of the stomachs positively correlated with at least two body parameters of the birds. A positive correlation for the relation of GL to BL, TL, SL; GWi to BW, BL; GW to BW, BL; GGL to BW, TL, SL were shown. No relationship between GSL and gizzard measurements was noticed. But GSW was in a positive correlation with GWi and GW.

Key words: Common Scoter *Melanitta nigra nigra,* morphometry, glandular stomach (proventriculus) ventriculus glandularis, muscular stomach (gizzard, ventriculus), ventriculus muscularis.

Морфометрическая характеристика железистого и мускульного желудков синьги *Melanitta nigra* (Aves, Anseriformes), зимующей на польском побережье Балтики. Дзяла-Щепаньчик Е. — Материалом для исследований послужили желудки 52 особей синьги *Melanitta nigra,* полученные зимой в западных районах польского побережья Балтики. Были определены 6 параметров желудков: масса (GSW) и длина (GSL) железистого желудка, масса (GW), длина (GL), ширина (GWi) мускульного желудка и общая длина обоих желудков (GGL), а также 4 измерения, описывающие размеры тела птиц: масса (BW) и длина (BL) тела, длина грудины (SL) и длина цевки (TL). Исследовали диморфические различия, связанные с полом и возрастом птиц в объеме средних величин желудочных параметров и показателей их относительных размеров. Анализировали зависимости между величинами желудочных параметров и размерами тела птиц. Несмотря на четко обозначенный половой диморфизм по размерам тела птиц в пользу самцов, только по 3 параметрам GWi, GWL и GGL и по параметру GGL/SL (длины обоих желудков относительно длины грудины) селезни достигали действительно больших величин, чем утки. Птицы в возрасте adultus и immaturus как в группе самцов, так и самок не отличались размерами тела и в большинстве по средним величинам желудочных параметров. Только в группе самок взрослые особи характеризовались более тяжелым мускульным желудком, чем молодые, а взрослые особи обоих полов имели более широкий мускульный желудок, чем молодые. Кроме GSL и GSW остальные параметры желудков коррелировали положительно по крайней мере с двумя параметрами тела птиц. Определена положительная корреляция для

связи GL с BL, TL и SL; GWi с BW и BL; GW с BW и BL; GGL с BW, TL и SL. Не обнаружена зависимость между GSL и измерениями мускульного желудка. Однако GSW находилась в положительной корреляции с GWi и GW.

Ключевые слова: синьга, *Melanitta nigra nigra*, морфометрия, железистый желудок, ventriculus glandularis, мускульный желудок, ventriculus muscularis.

Introduction

A characteristic feature of the alimentary system in birds is the presence of two stomachs – the front one – glandular stomach and the rear one – the muscular stomach (gizzard). Their shape and mutual size proportions are characterised by interspecific variability and, to a lesser extent, intraspecific variability. The former is a result of adaptation of individual species to taking and digesting food of a specific kind. Whereas individual variability may be connected, among other things, with genetic and hormonal conditions, parasite infections, amount and kind of available food (Ankney, 1977; McLeland, 1979; Duke, 1997). Anseriform birds are an immensely varied ecological group. They represent all three trophic types – predatory, omnivorous and herbivorous birds. Belonging to this order Common Scoter *Malanitta nigra nigra* (L., 1758) is classified as a predatory bird. It represents tribe Mergini from a sub-family ducks Anatinae (del Hoyo et al., 1992). It feeds by diving. The species has well developed both stomachs – glandular stomach and gizzard. It nests in the taiga and winters on not freezing seas of Europe (del Hoyo et al., 1992). The species is numerously migrating in Poland and winters on the Baltic (Tomiałojć, Stawarczyk, 2003).

The purpose of this study is to present a morphometric characteristic of both stomachs – glandular stomach and gizzard – of wintering common scoters in relation to age, sex, and the birds' body weight.

Material and methods

The study includes stomachs of 52 common scoters *Melanitta nigra* individuals – 32 males (5 immature ones and 27 adults) and 20 females (11 immature ones and 9 adults). Dead birds were collected in autumn and winter seasons in the years 1993—2000 in the seaside areas of the western part of the Polish Baltic coast. Common scoters had died in fishing nets while diving for food. The birds were divided into age categories – immature birds, under one year of age, and adults, over one year, sexually mature. Four measurements describing the birds' body size were established: body weight BW (exact to 10 g) and three linear measurements: body length, measured from beak to the end of the rump (with soft tape, exact to 0.5 mm), sternum length SL (exact to 0.5 mm), tarsus length TL (exact to 1.0 mm) – made according to A. Dziubin and E. Cooch's (1992) suggestion. The stomachs' morphometry included: glandular stomach weight (GSW) and length (GSL), gizzard weight (GW), length (GL) and width (GWi). The stomachs were separated according to differences in the structure of the mucous membrane lining them. The gizzard's length was a fragment between *isthmus venticuli* and the furthest point from it; the stomach's width was the fragment perpendicular to the abovementioned one situated between the points with the furthest distance between each other (fig. 1). The linear parameters of both stomachs were measured exact to 1mm. The stomachs weight was established exact to 0.01 g after cleaning them from chyme and drying with filtration tissue. The work also analyses the value of combined length of both stomachs (GGL), which was a sum of those two organs' measurements.

The statistical study of results consisted of establishing differences between males and females and between age categories of the birds in absolute average values of the stomachs measurements and average values of selected indices of relative size of those organs using t-Student test. The strength of interrelationships occurring between the values of stomachs' parameters and the values of parameters describing the birds' body size and between the parameters of both stomachs were also examined. For this reason appropriate Pearson's linear correlation coefficients (r) were established.

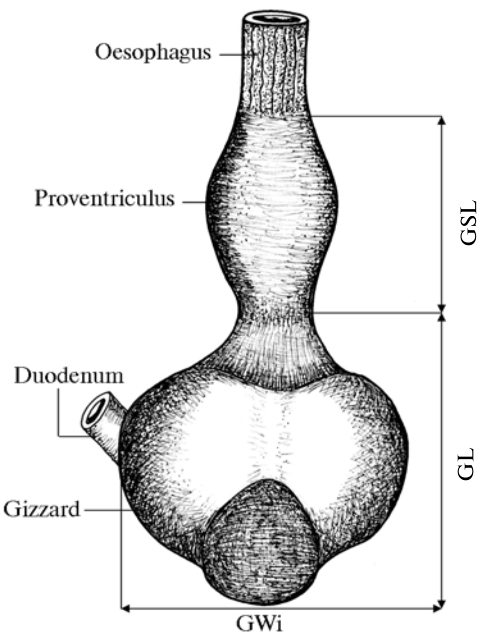


Fig. 1. Stomach of the Common Scoter *Melanitta nigra* (GSL – length of the proventriculus, GL – length of the gizzard, GWi – breadth of the gizzard)

Рис. 1. Желудок синьги *Melanitta nigra* (GSL – длина железистого желудка, GL – длина мускульного желудка, GWi – ширина мускульного желудка)

Results

No sexual dimorphism was noticed in the examined group of common scoters in the size of glandular stomach measurements and gizzard length, despite proved and statistically confirmed difference in the parameters describing body size between males and females. The males and females differed significantly in the gizzard width and weight, and in combined length of both stomachs, where drakes had higher values of those parameters than ducks (table 1).

The comparative analysis of individuals belonging to the groups of adults and immature birds within the same sex showed the lack of statistically significant differences in body measurements and in most of stomachs' parameters. Only adult individuals in the groups of drakes and ducks had significantly wider gizzards than immature individuals; and adult females had heavier gizzards than immature individuals of this sex (table 2).

Dimorphic differences relating to the indices of relative value of selected parameters of the stomachs were only visible in case of combined length of those two organs related to sternum length, in which females were characterised with higher relative length of both stomachs than males. In remaining four analysed indices of relative stomachs' size no differences were noted between drakes and ducks (table 3).

Gizzard parameters and combined length of both stomachs positively correlated with at least two, out of four, measurements describing the birds' body size. A positive correlation for the relation of GL to BL, TL end SL; GWi to BW end BL; GW to BW

Table 1. Differences in absolute body and glandular stomach and gizzard parameters between males and females of the Common Scoter *Melanitta nigra*

Таблица 1. Отличия абсолютных параметров тела, железистого и мускульного желудков между самцами и самками синьги *Melanitta nigra*

Measurements	$\bar{x}$ ± SD CV		M VS. F	$\bar{x}$ ± SD CV M + F n = 52
	M n = 32	F n = 20		
BW	1345.94±98.99 7.3	1183.0±84.54 7.1	t = 6.10 p ≤ 0.0001	1283.27±122.58 9.5
BL	429.84±11,53 2,7	407±10,69 2,6	t = 7.14 p ≤ 0.0001	421.06±15.79 3.7
TL	45.23±1.23 2.7	43.09±1.3 3.1	t = 5.84 p ≤ 0.0001	44.41±1.65 3.7
SL	100.69±5.61 5.6	93.45±4.51 4.8	t = 4.87 p ≤ 0.0001	97.91±6.27 6.4
GSL	35.49±3.97 11.2	34.26±3.25 9.5	NS	35.02±3.73 10.6
GSW	3.86±0.46 11.9	3.82±0.63 16.5	NS	3.84±0.53 13.7
GL	54.08±3.71 6.9	52.55±1.98 3.8	NS	52.55±1.98 3,8
GWi	56.53±4.01 7.1	51.48±4.64 9.0	t = 4.15 p ≤ 0.0001	54.59±4.90 9.0
GW	48.38±7.72 15.9	41.20±9.1 23.3	t = 2.97 p ≤ 0.001	45.62±9.11 20.0
GGL	89.57±4.96 5.5	86.82±4.15 4.8	t = 2.07 p ≤ 0.05	88.51±4.81 5.4

Note. M — males; F — females; $\bar{x}$ — arithmetic average; SD — standard deviation; CV — coefficient of variation; t — value of t-Student's statistics; NS — statistically insignificant differences; p — level of significance; BW — body weight (g); BL — body length (mm); TL — tarsus length (mm); SL — sternum length (mm); GSL — absolute length of the glandular stomach (mm); GSW — absolute weight of the glandular stomach (g); GL — absolute length of the gizzard (mm); GWi — absolute breadth of the gizzard (mm); GW — absolute weight of the gizzard (g); GGL — absolute length of the glandular stomach and gizzard (mm).

Table 2. Differences in absolute body and glandular stomach and gizzard parameters between immature and adult individuals of the Common Scoter *Melanitta nigra*

Таблица 2. Отличия абсолютных параметров тела, железистого и мускульного желудков между незрелыми и взрослыми особями синьги *Melanitta nigra*

Measurements	$\bar{x}$ ± SD CV		M_{Ad} VS. M_{Im}	$\bar{x}$ ± SD CV		F_{Ad} VS. F_{Im}
	M_{Ad} n = 27	M_{Im} n = 5		F_{Ad} n = 9	F_{Im} n = 11	
BW	1350.7±105.8 7.8	1320±46.37 3.5	NS	1217.8±74.9 6.1	1154.5±84.3 7.3	NS
BL	430.93±12.09 2.8	424±5.5 1.3	NS	407.22±13.02 3.2	406.82±9.02 2.2	NS
TL	45.16±1.32 2.9	45.6±0.49 1.1	NS	43.06±0.93 2,2	43.11±1.68 3,9	NS
SL	100.32±5.92 5.9	102.72±3.14 3.1	NS	94.68±4.26 4.5	92.44±4.65 5,0	NS
GSL	35.50±4,26 12.0	35.44±2.02 5.7	NS	33.44±3.26 9.7	34.93±3,24 9.3	NS
GSW	3.83±0.47 12.3	4.0±0.40 10.1	NS	3.83±0,61 15.9	3.81±0,68 17.7	NS
GL	53.75±3.51 6.53	55.9±4.65 8.3	NS	52.41±2.52 4.8	52.67±1.54 2,9	NS
GWi	57.12±4,03 7.1	53.32±1.96 3.7	t = 2.045 p ≤ 0.05	54.21±4.14 7.6	49.25±3.89 7.9	t = 2.75 p ≤ 0.05
GW	49.41±7.97 16.1	42.81±1.85 4.3	NS	47.32±9.0 19.0	36.19±7.02 19.4	t = 3.109 p ≤ 0.0001
GGL	89.24±5.04 5.6	91.34±4.57 5.0	NS	85.85±5.07 5.9	87.61±3.23 3.7	NS

Note. M – males; F – females; ad – adult individuals; im – immature individuals; – arithmetic average; SD – standard deviation; CV – coefficient of variation; t – values of t-Student's statistics; NS – differences statistically insignificant; p – level of significance. Measurements symbols – see table 1.

Table 3. Comparison of indices of relative values of glandular stomach and gizzard measurements in males and females of the Common Scoter *Melanitta nigra*

Таблица 3. Сравнение индексов относительных значений промеров железистого и мускульного желудков у самцов и самок синьги *Melanitta nigra*

Index	$\bar{x}$ ± SD CV		M VS. F	$\bar{x}$ ± SD CV
	M n = 32	F n = 20		M + F n = 52
GL/BL[1] x 100%	12.58±0.80 6.4	12.92±0.53 4.1	NS	12.71±0.72 5.7
GL/TL[2]	1.19±0.08 6,3	1.22±0.04 3.8	NS	0.55±0.04 6.7
GWi/BW[3] x 100%	4.21±0.36 8.6	4.36±0.41 9.3	NS	4.27±0.38 8.9
GWi/BL[1] x 100%	13.16±0.96 7.3	12.65±1.06 8.4	NS	12.69±1.02 7.9
GW/BW[4] x100%	3.60±0.55 15.2	3.47±0.71 20.4	NS	3.55±0.61 17.2
GGL/SL[5]	0.89±0.05 6.1	0.93±0.06 6.6	t = – 2.43 p ≤ 0.05	0.91±0.06 6.6

Note. M – males; F – females; x̄ – arithmetic mean; SD – standard deviation; CV – coefficient of variation; t – value of t-Student statistics; NS – non-significant statistical differences; p – significance level.

[1] Index of relative organ length (width) – as a relation of organ length (width) to body length (mm/mm BL) expressed as percentage.

[2] Index of relative organ length – as a relation of organ length to tarsus length (mm/mm TL).

[3] Index of relative organ length (width) – as a relation of organ length (width) to body weight (mm/100 g BW).

[4] Index of relative organ weight – as a relation of organ weight to body weight (g/g BW) expressed as percentage.

[5] Index of relative organ length – as a relation of an organ length to sternum length (mm/mm SL).

Table 4. Coefficients of correlation for interdependent among measurement of glandular stomach and gizzard and parameters of body in the Common Scoter *Melanitta nigra* (parameter symbols see table 1)

Таблица 4. Коэффициенты корреляции для взаимозависимых промеров железистого и мускульного желудков и параметров тела синьги *Melanitta nigra* (условные обозначения параметров см. табл. 1)

	BW	BL	TL	SL	GSW	GL	GWi	GW	GGL
GSL	NS	NS	NS	NS	NS	NS	NS	NS	0.74***
GSW	NS	NS	NS	NS	—	NS	0.33*	0.39**	NS
GL	NS	0.40**	0.43**	0.42**		—	NS	NS	0.63***
GWi	0.54***	0.48***	NS	NS			—	0.87***	NS
GW	0.51***	0.44***	NS	NS				—	NS
GGL	0.29*	NS	0.35**	0.41**					—

* Siglificant at < 0.05.
** Siglificant at < 0.01.
*** Siglificant at < 0.001.
NS – non-siglificant.

end BL; GGL to BW, TL end SL were shown. Gizzard length and weight were not in any relationship with body parameters of the examined group of common scoters (table 4).

No relationship between parameters of glandular stomach's length and gizzards measurements. Glandular stomach weight positively correlated with gizzard width and its weight. The strongest relationship was noted for the relation of gizzard width and this organ's weight (table 4).

Discussion

Common Scoters have well developed both stomachs (fig. 1). The average weight of empty glandular stomach in the examined group of common scoters was 35 g, and of empty gizzard – 45.6 g, with the average birds' body weight of 1283.3 g. In R. I. Goudie and P. C. Ryan's studies (1991) conducted on 17 individuals of wintering common scoters, the average gizzard weight reached the value of 42.8 g (with the average bird's body weight of 1038 g). The shape and mutual proportions in the size of both stomachs are related to the kind and amount of food the birds feed on (Pendergast, Boag, 1973; Paulus, 1982; DuBowy, 1985; Kehoe, Ankney, 1985; White, Bolen, 1985; Richardson, Wooler, 1986; 1990; Duke, 1997). G. G. Barnes and V. G. Thomas (1987), examining 18 species belonging to family *Anatidae* divided into three trophic group, proved that gizzards of predatory ducks were lighter than stomachs of omnivorous and herbivorous species. W. P. Kehoe and C. D. Ankney (1985) came to similar conclusions examining 5 species of ducks from the species *Aythya* – the Redhead *Aythya* a*mericana*, feeding on plant food with a lot of indigestible fibre, had considerably heavier gizzard than remaining species that ate food less burdened with this ingredient. In relation to predatory ducks from the tribe *Mergini*, the studies indicate the tendency of the occurrence of heavier gizzards in those species that feed on bivalves with large shells (Goudie, Rayan, 1991). The Common Scoter is classified as a species feeding on animal food. Only in summer it eats small amounts of plant food (del Hoyo et al., 1992). L. Stempniewicz (1986), examining wintering common scoters on the Polish Baltic coast, showed that the birds' diet consisted mainly of bivalves, which constituted 93.8% of food mass. Common Scoters *Melanitta nigra americana* wintering on the US coast ate mainly bivalves like the *Mytilus edulis* and *Yoldia limatula*, which constitute altogether 79.7% of chyme in oesophagus and gizzard (McGolvrey, 1967). Goude and Ankney (1986), in comparative studies of four wintering duck species from the tribe *Mergini*, draw attention to small diversity of common scoters' food comparing to other species – the Coomon Blue Mussel *Mytilus edulis* constituted 98% of wet food mass in those birds' oesophagus. Moreover, common scoters were characterised by relatively short time of feeding comparing to other species

from the tribe *Mergini* (Goudze, Ankney, 1986). The examined common scoters were collected in winter months, in the period when the birds feed only on animal food, which probably influenced the value of both stomachs' parameters.

The coefficient of variability for some morphometric features of stomachs in the examined group of common scoters reached quite high values and could be a result of morphological and anatomical variability of birds collected during seven years in various winter months (from October to March). The variability of the structure of digestive organs within a species may have various grounds. Birds' stomach is a dynamic organ and is subject to continuous morphological changes in time (Kehoe et al., 1988; Strack, 1999; Barboza, Jorde, 2002). Many researchers point out that changes registered in alimentary tract in omnivorous and herbivorous birds especially become visible in the gizzard as a result of changing food containing fibre (Moss, 1972; Burton et al., 1979; Whyte, Bolen, 1985). M. W. Tome (1984) draw attention to changes taking place in gizzard weight of females of the Ruddy Duck *Oxyura jamaicensis* in the nesting period as a result of qualitative changes of food taken at that time by the birds. The amount of eaten food can also significantly influence the birds' digestive system (Sabvory, Gentile, 1976; Ankney, 1977; Raveling, 1979; Drobney, 1984; Ankney, Scott, 1988).

In the examined group of common scoters the lack of sexual dimorphism was noticed in the average values of glandular stomach and gizzard length, despite clear difference in the body size between males and females. Clear differences between drakes and ducks were visible in relation to gizzard width and weight, as well as both stomachs length. Differences, or their lack, in respect to the parameters describing the size of stomachs between males and females of common scoters may have various reasons. A lot of authors point out to periodical or permanent variability of males' and females' diet of many bird species, and consequently a morphological variability of their digestive organs. S.-A. Bengston (1971), comparing the food of females and males of six representatives of sub-family *Anatinae* showed significant differences in food preferences between sexes of individual species. In this author's (Bengston, 1971) research, mainly larvae of *Chiromonidae* were found in common scoter females' oesophagus, which constituted 64% of wet chyme of this organ. On the other hand, chyme in oesophagus of this species' males consisted mainly of fish eggs (86% of wet food mass of the oesophagus). In research carried out on the wintering Tufted Duck *Aythya fuligula*, differences in food preferences between females and males of this species also concerned the mussels' size – drakes ate mussels *Corbicula japonia* with bigger shells than ducks did (Oka et al., 1999). C. D. Ankney and A. D. Afton (1988) pointed out at differences in the percentage of individual food components and differences in gizzard weight between males and females of Northern Shoveler *Anas clypeata* in the nesting period.

The analysis of dimorphic differences connected with sex in respect to the indices of relative stomach size of the examined group of common scoters showed that females reached higher values of relative length of both stomachs (calculated in relation to sternum length) than males. However, in respect to other parameters of relative stomachs' size related to remaining body measurements, no differences between drakes and ducks were found. Perhaps sternum length and both stomachs length – parameters close to the value of the coefficient of variability in the groups of males and females, better characterise dimorphic differences. Supposedly, the differences relating to digestive organs size between males and females may also have genetic background. M. R. Miller's (1974) experiment carried out on wild mallards kept in captivity showed that smaller females had longer intestines than bigger males, despite the fact that they were fed on the same forage. The author (Miller, 1974) suggests that the Mallard's females (*Anas platyrhynchos*) have genetically conditioned better ability to adapt their morphology of digestive organs to changes of diet that males of this species have. C. D. Ankney (1997), examining males and females of the Lesser Snow Geese *Chen caerulescens caerulescens*

in the nesting period, attributes differences in changes occurring in gizzard weight in both sexes both to the influence of the changing diet and inborn features of this species.

The lack of dimorphism connected with age in respect to most stomach parameters in the examined group of common scoters may be attributed to unequal participation of adult and immature birds. It may also be a result of the lack of differences in body size between the birds' age groups. Also no significant difference was proven in gizzard weight between immature and adult individuals of the Black Duck *Anas rubripes* not differing in body size (Reinecke et al., 1982). But in respect to jejunum and ileum of wintering immature and adult common scoters that did not differ in body size, it was shown that the individuals from the group of immature birds had this organ longer than adult individuals (Działa-Szczepańczyk, 2004). R. J. Whyte and E. G. Bolen (1985) showed differences in gizzard weight both between males and females as well as between age groups of adult and juvenile birds in mallards *Anas platyrhynchos* examined in the period from autumn to early spring – but statistical significance of those differences was not studied.

In the examined group of common scoters no relationship of glandular stomach with the birds' body measurements were noticed. Gizzard parameters, however, positively correlated with at less two measurements describing common scoters' body size. Presumably, both stomachs react differently to the change of diet, which is reflected, among others, in the relationship of those organs' parameters with the birds' body measurements. Perhaps common scoters' glandular stomach is subject to faster morphological modifications under the influence of food changes than the gizzard, and changes taking place in it are not parallel to the changes in the birds' body build. In interspecific comparisons performed on 19 representatives of waders *Charadrii* it was shown that both stomachs' weight positively correlated with this group of birds' body weight (Piersma et al., 1993). In K. C. Richardson and R. D. Wooler's (1986) studies, however, gizzard weight of six species of *Passeriformes* feeding on honey did not come into any relationship with those birds' body weight. Perhaps the obtained results were associated with the diet of the compared group species. It the group of *Charadrii*, there are herbivorous and omnivorous species, feeding on low-calory food containing indigestible fibre. The food of the studied of *Passeriformes* (honey) is more easily assimilated.

The lack of the relationship of glandular stomach length with gizzard's parameters may also indicate a different reaction of both organs to the diet changing in time. The dynamics of morphological changes taking place in glandular stomach under the influence of food may be similar to the reaction of the intestine. This organ in water birds adapts so fast to the changing died that its size may be used as a good indicator of food preferences of this group of birds (Miller, 1974, 1975). As many experiments prove, gizzard may react differently to the change of food than other parts of the digestive system. An experiment performed on the Mallard *Anas platyrhynchos* kept in captivity proved considerable differences in gizzard's reactions to higher dose of fibre in the diet comparing to the intestine – gizzard weight, after initial rise, dramatically decreased after fifteen days of the experiment, whereas intestine length had a rising tendency (Kehoe et al., 1988). S. A. Halse (1984, 1985) noticed a considerable increase of gizzard weight in the moulting period of Spur Winged Goose *Plectropterus gambensis* and Egyptian Goose *Alopochen aegyptiacus*. The author (Halse, 1984, 1985) suggests that the increase of weight of this organ may have been influenced, apart from the change of food in that period, also by another factor because the changes in gizzard were bigger than in other parts of the digestive system in both species.

Conclusions

Sexual dimorphism was only evident in three parameters: gizzard width and weight and both stomachs' length – drakes had significantly higher values than ducks. In most parameters of stomachs related to body measurements, no significant differences

between females and males were noticed; only the index of relative length of both stomachs related to sternum length occurred to be higher in ducks than in drakes.

No significant differences were found between adult and immature birds in body weight and the value of most stomachs' parameters. A positive correlation for the relation of GL to BL, TL, SL; GWi to BW, BL; GW to BW, BL; GGL to BW, TL, SL were shown.

Apart from glandular stomach length and weight, other stomachs' parameters positively correlated with at least two parameters describing the birds' body size.

No relationship between glandular stomach length and gizzard parameters was found. Glandular stomach weight was in the positive correlation with gizzard width and weight.

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